Power System Examples

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Session Overview

- Review different power system categories
- Provide examples of different power systems
- Provide a little information on a number of power systems that you will hear about over the next few days

Renewable Power Systems

- **Renewable power system can be used to cover a wide range of needs. These include:**
  - **Dedicated use:** Water pumping/ice making.
  - **House systems:** Power systems for individual buildings, dispersed generation.
  - **Small Power Systems:** Providing power to a confined community or large application.
  - **Community Power Systems:** Power provided to a large community with large loads
  - **Wind/Diesel Systems:** Large communities with large loads

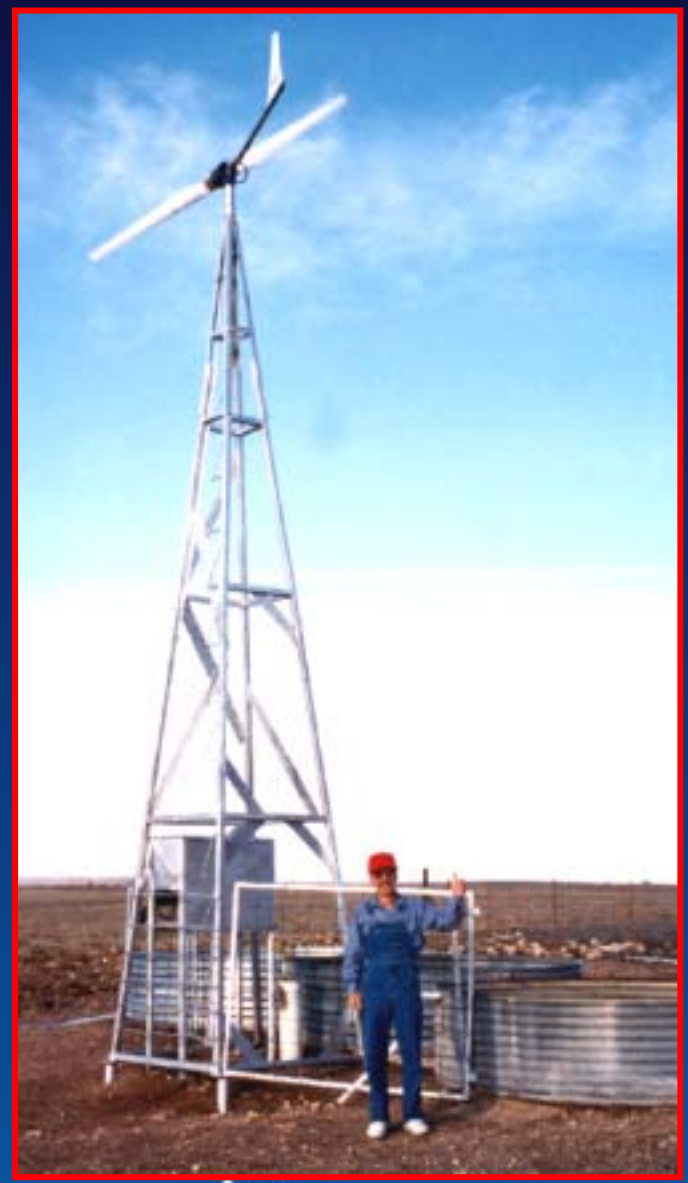
Agricultural Water Pumping

- Livestock watering at the Bledsoe Ranch Colorado, USA
- PV, Mechanical wind and diesel backup solves problems with seasonal variations in resource

NEOS Corporation

Direct Water Pumping

- Ranch near Wheeler, Texas
- Water-pumping for 120 head of cattle
- Whisper 1000 wind turbine,
  1 kW, 9-ft rotor, 30-ft tower



Small Power Systems

- Systems do not have a dispatchable backup generator like most hybrids
- Very simple architecture:
  - Turbine, PV, Disconnects, Batteries
  - DC Loads or AC power through an inverter
- Primarily PV dominated for small loads, wind has potential at larger loads.
- In many instances a combination of PV and wind make most sense
- Can vary in size, power output

Solar Home System

- **Provide entry level of service**
  - Lighting, radio
  - DC service
- **Expandable in size, >20W**
- **Cost ~$700 for small unit**
- **Developed market**

Wind/PV Home Systems

- Provide more energy
- AC Power
- Higher output
- Lower $/kW

Inner Mongolian wind/PV system

Micro-Grid Power Systems

- Small systems with demands up to ~100kWh/day load (15 kW peak load)
- Components of wind, PV, batteries and conventional generators
- Provide AC and potentially DC power
- Use of batteries to store renewable energy for use at night or low renewable times
- Generator used as backup power supply
- Mature market

Subax, Xinjiang, China

- Small community of 60 homes in very remote part of Western China
- Power System
  - 2 BWC excel (8kW) turbines
  - 2 15 kVA Inverters
  - 4 kW PV
  - Low Maintenance battery bank
  - 30kVA diesel generator

Isla Tac, Chile

- Island community with Health post, school and 82 homes
- Power System:
  - 2x7 kW wind turbine s
  - Flooded batteries
  - 2 x 4.5 kW inverter
  - 16 kWA backup gas generator

Santa Cruz Island, California, USA

- Remote Telecommunications station
- Power System
  - **PV array**
  - **Two wind turbines**
  - **No Backup generator**
- Vary costly access/site visits
- Remote operation and monitoring of system

Northern Power Systems

Mt. Newall, Antarctica

- Science Foundation Station project
- Repeater and Seismic monitoring station
- Power System
  - **3.3 kW PV array**
  - **Diesel generator**
  - **HR3 wind turbine**

Northern Power Systems

Woodstock, Minnesota

- Wind farm maintenance shop and office
- Electric loads include lighting, PC, and shop tools
- Passive solar day-lighting, corn used for space heat
- Installed cost $6,800 in 2001 (grid extension alternative: $7,500)
- 1200 ft^2 shop, 900 ft^2 office
- Whisper H40 wind turbine, 900 W, 35-ft tower
- PV panels, 500 W
- 24 VDC battery, 750 Ah
- 4-kW inverter, 120 VAC single phase

Mini-Grid Power Systems

- Larger systems with demands up to ~700kWh/day load (100 kW peak load)
- Same components used as in Micro-Grids, just more of them and larger
- Use of batteries to store renewable energy for use at times of light loading
- Generator used to supply large loads
- Mature market though fewer examples
- Provide AC power

Dangling Rope Marina, Utah, USA

- Remote National Park Center
- 160 kW PV / Propane generator hybrid system

San Juanico, Mexico

Remote fishing community of 400 people with tourism

Power System

- 17 kW PV
- 70 kW wind
- 80 kW diesel generator
- 100 kW power converter/controller

Advanced monitoring system

Low Penetration

- Capital cost of between $1,000-1,500/ per kW of wind capacity, excluding diesel units and plant BOS
- Easy integration with existing diesel system, little or no diesel modifications required
- Modest fuel savings of up to ~20% possible.
- System support requirements:
  - Wind turbine maintenance.

Ascension Island

Four NEG-Micon 225 kW turbines installed in 1996.

- U.S. Air Force installation on British island in mid-Atlantic ocean.
- Prime diesel generation with rotary interconnect to British 50 hertz system
- Pacific Electric Industries

Kotzebue, Alaska

- 11 MW remote diesel power station in Northern Alaska
- 2 MW peak load with 700kW minimum load
- Installation of 10 AOC 15/50, 50 kW wind turbines and 1 NW 100, 100kW wind turbine
- KEA, Island Technologies, AOC

Medium Penetration

- Capital cost of between $1,500-2,500 per kW of wind capacity, excluding diesel units and plant BOS.
- Some diesel controls modifications necessary
- Usually must install/integrate secondary loads to regulate minimum diesel loading.
- Requires relatively simple supervisory control
- Greater fuel savings possible, up to ~40%
- Additional support requirements:
  - Wind turbine maintenance
  - Secondary load maintenance

Coyaique, Chile

- Isolated Community
- Private Utility
  - 2 MW Wind, 4.6 MW Hydro, 16.9 MW Diesel
- Remote installation

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San Clemente Island, California

- U.S. Navy island 53 miles off San Diego
- Diesel powered grid
- Average demand 850-950 kW
- Peak demand 1,400 kW
- Pacific Electric Industries

SCI Diesel Plant

- Four generators
- 3 NEG-Micon 225 kW turbines

Yearly impact -

- $97,000 fuel savings
- 871,785 Ton CO_2 avoided

Selawik, Alaska

- Small AVEC community in northern Alaska
- Installation of 4 AOC 15/50, 50 kW wind turbines and dump loads
- Part of a diesel plant retrofit project

- AVEC, Entegrity/AOC, Sustainable Automation

High Penetration

- **Capital cost between $2,500-4,000 per kW of wind capacity, excluding diesel units and plant BOS**
- **Significant diesel controls modifications may be necessary and new diesel control panels highly recommended**
- **Must install integrated secondary loads**
- **Requires sophisticated supervisory control system**
- **Some control of wind turbine output recommend**
- **Highest fuel savings possible, up to ~70%**
- **Additional support requirements:**
  - Active assessment to insure system maintains adequate control of system power quality.
  - Wind turbine maintenance
  - Secondary load maintenance

Wales Alaska Wind Diesel System

High penetration system

- 80kW average load with 130kW of wind power
- Short term battery storage
- Resistive loads used for heating and hot water
- AVAC, KEA and NREL

St. Paul Alaska, USA

Island in the middle of the Bering Sea
Peak load of 160kW
Cost of Power, ± $0.21/kWh
Waste energy used for heating
TDX and Northern Power Systems